2019 STREAM HEALTH ASSESSMENT & TOTAL MAXIMUM DAILY LOAD (TMDL) REPORT

Prepared by

City of Bothell™

Public Works
18415 101st Avenue NE
Bothell, WA 98011
425-806-6800
www.bothellwa.gov/surfacewater
Contact: Chris Hall, Surface Water Program Coordinator

Preface

This report was written to document stream health in Bothell and the impacts from urban stormwater runoff. Information required by the Western Washington Phase II Municipal Stormwater Permit and the North Creek and Swamp Creek Total Maximum Daily Load (TMDL) reports are also included in this report. The intended audience for this report is internal staff, City Council, state agencies, local government, Bothell customers, and anyone else interested in streams and stormwater in Bothell, Washington.

Why do we care about stream health and stormwater?

Stream health and water quality are important for human health and recreation, aquatic organisms, and fish habitat. Stormwater flow, resulting from rainfall, is an important aspect to the overall health of a watershed in urban areas. Stormwater infrastructure, like pipes and storm drains, is a required component of development in urban areas to convey rainwater away from buildings, roads, parking lots, and other areas. As stormwater flows over developed lands, it picks up pollutants and discharges them into local streams and lakes. The rain mixes with materials such as:

- Petroleum products, metals, and other fluids from vehicles
- Bacteria from pet waste and failing septic systems
- Soil from construction sites
- Fertilizers and pesticides from lawns and gardens

This pollution contaminates local waters, impacts human health, harms fish and other wildlife, and disrupts natural stream flows. The figure below (King County, 2018) shows how urban stormwater runoff and water quality are related and gives insight on why monitoring freshwater resources in urban areas is important to protect people, property, and the environment.

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Introduction

City of Bothell conducts annual stream health and stormwater monitoring for water quality, stream physical habitat, and biologic health. We conduct monitoring in Bothell to meet the need for local information on surface water to protect people, property, and the environment. Along with the need for local information, we also use data collected from monitoring to meet requirements of the Western Washington Phase II Municipal Stormwater Permit (Phase II Municipal Permit) and two local Total Maximum Daily Load (TMDL) report requirements.

The Phase II Municipal Permit is a requirement for all municipalities that own or operate regulated small municipal separate storm systems (MS4). States develop TMDLs, as required by the federal Clean Water Act (CWA), to create an implementation plan for areas that are not meeting state Water Quality Standards for specific parameters. In the case of Bothell, both North Creek and Swamp Creek have TMDL requirements due to excessive fecal coliform bacteria levels that may pose a risk to human health and the environment. More information on fecal coliform bacteria can be found in the results: fecal coliform section.

Data collected from these monitoring efforts will be presented to local and state decision makers so resources can be directed most effectively. The City is committed to wise management of land and water for the benefit of current and future generations, while also meeting TMDL and the Phase II Municipal Permit requirements. One measure of success will be compliance with state Water Quality Standards and beneficial uses as designated by city, state, and federal standards.

Each year the City reports on annual stream health, with some years including more robust analysis such as trend detection from changes over time in stream health. For more information on trends and background data, see the 2018 Stream Health Assessment and Total Maximum Daily Load (TMDL) Report. This report can be viewed on the City's webpage at http://www.ci.bothell.wa.us/DocumentCenter/View/8659/2018-Stream-Health-Assessment-and-TMDL-Report-PDF.

Goals and Objectives

City of Bothell's monitoring goal is to measure and report our findings to internal staff, City Council, state agencies, and Bothell customers every year so they can determine next steps to protect and restore the chemical, physical, and biological integrity of the City's surface waters.

City of Bothell's monitoring objectives are to:

- Determine status and trends for streams within the City of Bothell for: temperature, dissolved oxygen, sediment loading, pathogens, physical habitat, and biological health. Data will be used as a baseline to measure overall water quality and changes in stream health over time.
- Screen for potential water quality issues in Bothell's watersheds through Illicit Discharge Detection and Elimination (IDDE), effectiveness monitoring, and source tracking surveys. IDDE monitoring is used for cleaning and reporting spills or illegal connections to the municipal stormwater system (MS4).
- Use monitoring data and land use information to inform City policy and land use rules, prioritize restorative actions, and direct future program monitoring efforts.
- Use the results from monitoring efforts to measure effectiveness of implementing the Phase II Municipal Permit, TMDL requirements, and Clean Water Act at the local scale.

Monitoring Locations

In 2019 the City collected monthly samples at ambient and Total Maximum Daily Load (TMDL) locations for temperature, dissolved oxygen, pH, conductivity, turbidity, and fecal coliform. Nutrients, metals, and total suspended solids (TSS) were collected quarterly at ambient and TMDL monitoring locations as well. Additionally, in 2019 the City began its' first year of watershed health monitoring. The City has a robust ambient monitoring program focused on discrete locations for long-term monitoring. This gave accurate data for long-term trend analysis but created data gaps in water quality in certain parts of the city.

To fill in data gaps, the City started taking samples for water quality, physical stream habitat metrics, and macroinvertebrates (stream insects) at randomized locations using protocols created by the EPA and Washington State Department of Ecology. Figure 1 shows all the sites that were sampled in Bothell in 2019 including ambient, TMDL, and watershed health monitoring sites.

In total, 11 sites were sampled monthly (with additional quarterly monitoring parameters) at ambient locations which included 5 TMDL sites. Another 12 sites were sampled using watershed health monitoring protocols. The City focused on critical in-stream water quality metrics along with known pollutants from urban stormwater which includes:

1. Temperature
2. Dissolved Oxygen
3. Fecal Coliform Bacteria
4. Sediment
5. Dissolved Metals
6. Nutrients

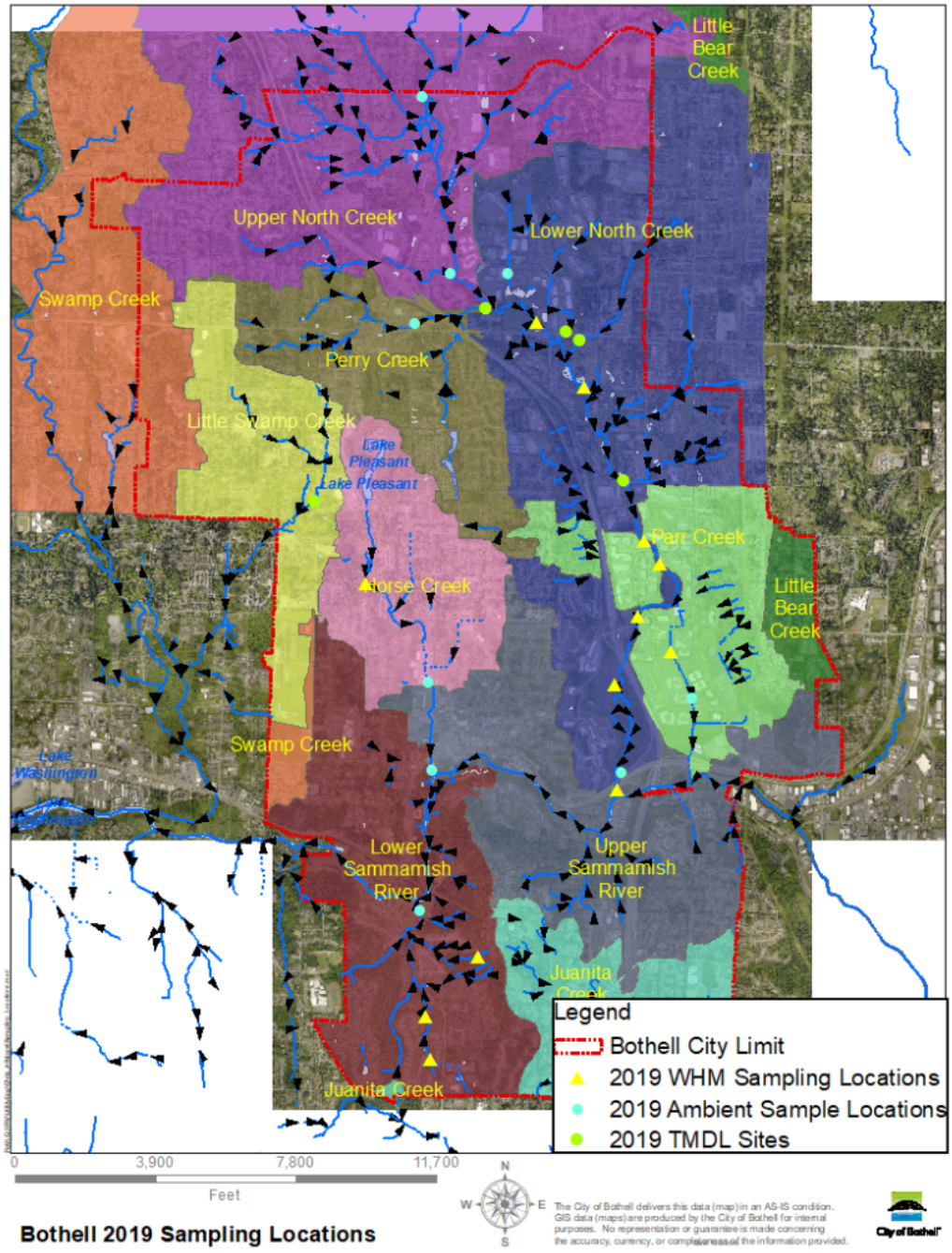


Figure 1. *Ambient, WHM, and TMDL sample locations for 2019.*

Results

In-stream Temperature

Increased temperature in streams affects many characteristics of aquatic organisms including mortality rates, physiology, and growth (Poole et al, 2001). Reports show negative effects of degraded temperature on juvenile and adult salmon in the Pacific Northwest (Richter & Kolmes, 2005). Increased stream temperature also negatively impacts dissolved oxygen levels in streams from the relationship of oxygen solubility in water with stream temperature. As temperature increases, the solubility of oxygen in water decreases resulting in less dissolved oxygen at higher stream temperatures. (NOAA, 2004).

During ambient monthly monitoring, 62% of sample sites did not meet water quality standards set by Department of Ecology (16° Celsius). At continuous temperature logging stations (data collected every 15 minutes), data shows 66% of sites fail to meet water quality standards as well. Continuous temperature sites give us the most accurate data due to the frequency of collection.

	Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Perry Creek	Upper North Creek
Ambient In-Situ Temperature	# samples	4	3	19	5	3	5
	Mean	15.95	15.647	14.884	15.352	14.883	15.474
	Max	16.83	16.74	17.08	17.18	15.6	16.79

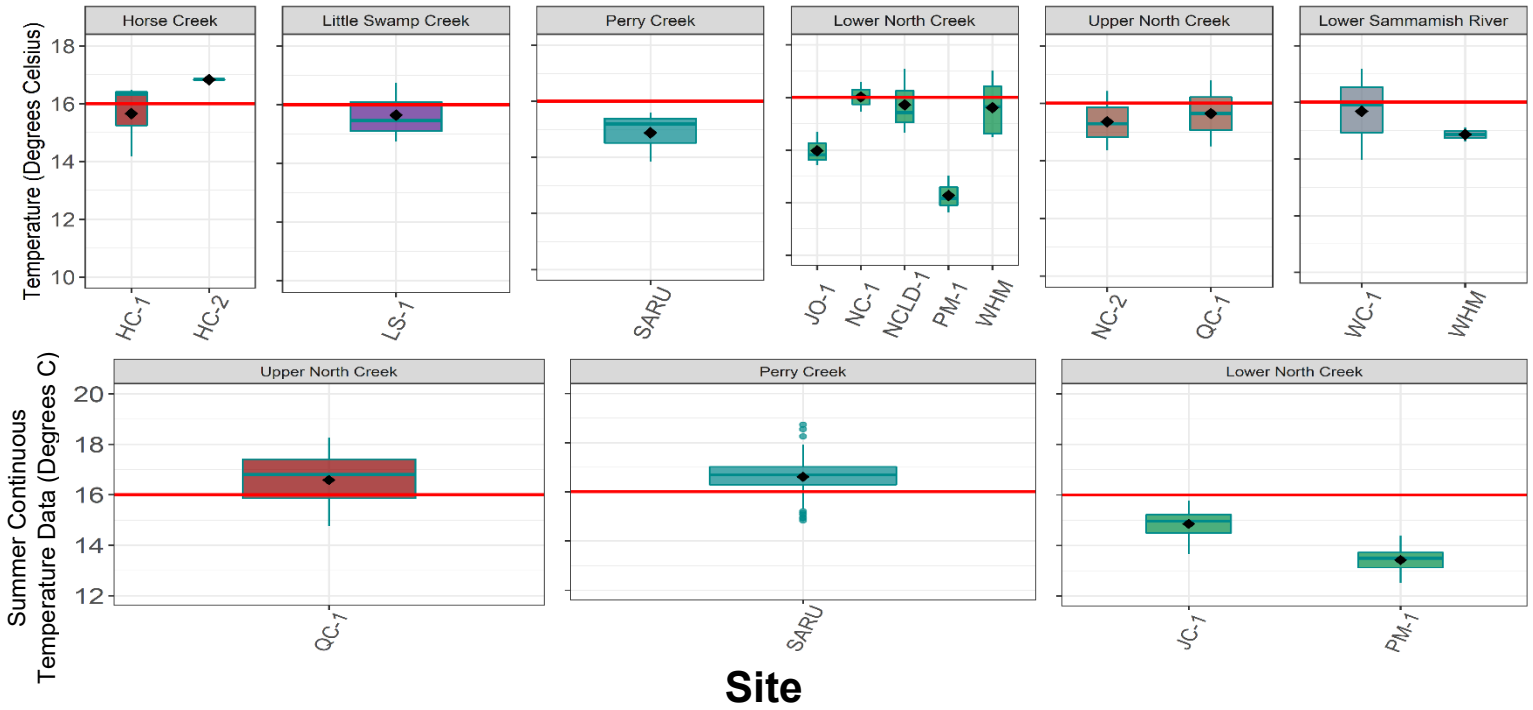
	Stats	Lower North Creek	Perry Creek	Upper North Creek
Continuous Temperature Loggers	# of samples	184	90	92
	Mean	14.14	16.613	16.587
	Max	15.758	18.74	18.275

How Does Stormwater Affect Stream Temperatures?

Stream temperatures are commonly a problem in developed watersheds due to loss of tree shading of stream corridors, impacts to cool groundwater inputs, and damming (Kaushal et al, 2010). With larger amounts of hard surfaces, such as roads and parking lots, rain water isn't able to infiltrate into the ground. Instead, rain water flows through catch basins and pipes straight into our local water bodies

Ambient air temperatures are also increasing globally and will continue to put pressure on in-stream organisms (USGCRP, 2018). With global climate change increasing temperatures, finding ways to decrease in-stream temperatures will be key.

By increasing the amount of shading around streams and increasing cold water inputs and refuges, Bothell can make streams more resilient to climate change and safer for fish.



Results: Dissolved Oxygen

The U.S. Environmental Protection Agency set recommended criteria for dissolved oxygen in freshwater for the protection of cold-water species (salmon). EPA's recommendation is based on data showing negative impairment on juvenile salmon from declining intragravel dissolved oxygen concentrations (Ecology, 2009). In-stream organisms use dissolved oxygen for respiration which can be lethal at low levels. Washington State Department of Ecology set water quality standards for surface water at 9.5 milligrams per liter (mg/L). If any sample taken is lower than 9.5 mg/L dissolved oxygen, that site fails to meet State water quality standards.

Similar to temperature, 62% of sites sampled over the summer failed to meet water quality standards during monthly monitoring for dissolved oxygen in Bothell. This is not surprising because of the correlation between temperature and dissolved oxygen. Generally, as temperature increases in water the ability to hold dissolved oxygen decreases.

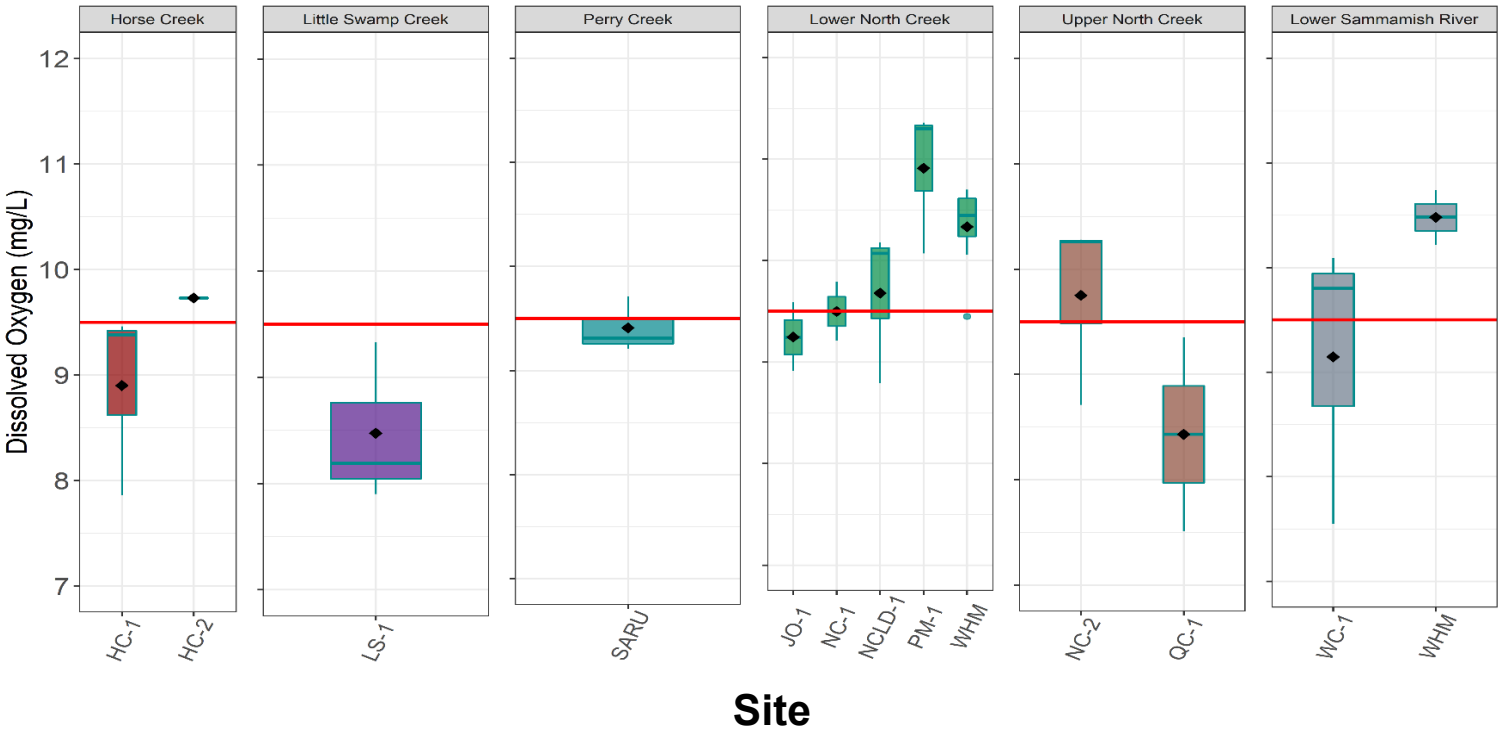
How Does Stormwater Affect Dissolved Oxygen?

All of the same factors that increase temperatures from stormwater and urbanization also decrease dissolved oxygen in streams. As temperatures in-stream increase, dissolved oxygen decreases. This will continue to be an issue as ambient air temperatures increase in the future.

Dissolved oxygen also decreases from Biologic Oxygen Demand (BOD) which increases with organic inputs such as sewage, pet waste, or dissolved organic matter such as leaves and debris.

By implementing the same methods to reduce temperatures in-stream we can also protect dissolved oxygen for aquatic organisms. Along with reducing temperatures, removing inputs from sewage such as leaky septic systems and cleaning up pet waste can help improve dissolved oxygen levels in local water bodies.

Dissolved Oxygen	Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Perry Creek	Upper North Creek
	N	4	3	19	5	3	5
	Mean	9.107	8.473	10.062	9.68	9.41	9.222
	SD	0.845	0.756	0.733	1.238	0.265	1.163
	Median	9.42	8.19	10.07	10.09	9.31	9.35
	Min	7.86	7.9	8.79	7.55	9.21	7.51
	Max	9.73	9.33	11.36	10.74	9.71	10.28



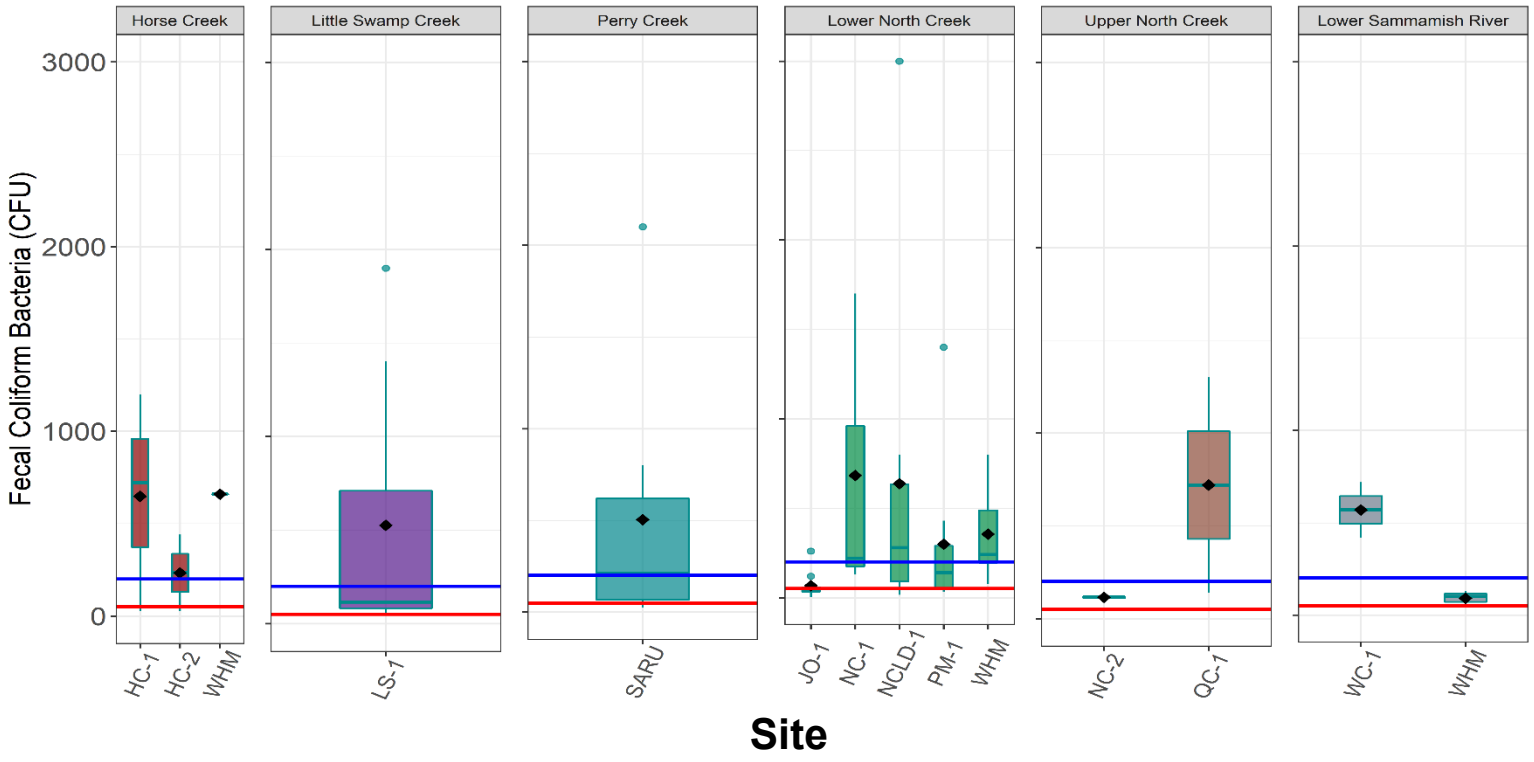
Results: Fecal Coliform Bacteria (TMDL Requirement)

Pathogens in surface water, such as streams or lakes, can cause significant human health impacts depending on the concentration and type of bacteria. Fecal coliform, a type of bacteria found in the intestines of warm-blooded animals, can be a sign of sewage waste, manure, or wildlife. To protect human health, Washington State Department of Ecology sets fecal coliform standards at a geometric mean of 50 Colony Forming Units (CFU) per 100 milliliters (mL) for extraordinary primary contact waters (Chapter 173-201A, WAC).

As a result of the fecal coliform bacterial pollution problem, Department of Ecology worked with local municipalities to develop the North Creek Fecal Coliform Total Maximum Daily Load Detailed Implementation Plan (Svrjcek, 2003) and Swamp Creek Fecal Coliform Bacteria Total Maximum Daily Load, Water Quality Improvement Report and Implementation Plan (Svrjcek, 2006). In the plans, Ecology established water quality monitoring requirements for local municipalities that collect, treat, and/or convey stormwater to these streams. As part of the City's stormwater permit, we are reviewing data to identify future new priority areas for source identification and elimination for fecal coliform sources.

All but one site (95%) sampled for fecal coliform failed to meet State standards for surface water. TMDL sites include: LS-1, SARU, JO-1, PM-1, and NCLD-1.

	Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Perry Creek	Upper North Creek
Fecal Coliform	N	6	12	48	5	1	12	4
	Mean	511.667	844.667	359.694	282.4	2400	504.667	417.5
	SD	451.228	1171.497	590.797	284.919	NA	659.114	588.466
	Median	550	120	135	130	2400	210	130
	Min	24	46	2	42	2400	26	110
	Max	1200	3400	3000	720	2400	2100	1300



How Does Stormwater Affect Fecal Coliform Bacteria?

Fecal coliform in streams come from many sources. Any feces from warm-blooded animals (human, pets, wildlife) all contains fecal coliform bacteria.

As such, fecal coliform can come from failing septic systems leaching fecal coliform into local waters, failing to pick up pet waste, and local wildlife feces.

One easy method to reduce fecal coliform in local water bodies is to pick up pet waste in bags and dispose properly in the garbage. Another way to reduce the fecal coliform issue is to inspect and maintain your septic system to keep it functioning.

Results: Sediment

Sediment in streams cause direct effects on aquatic organisms resulting in decreased growth rates, increased mortality, and depleted food availability (Henley et al, 2000). Two ways Bothell samples to determine the amount of sediment in streams are turbidity and total suspended solids (TSS). Turbidity is the amount of clarity lost in water due to suspended particles such as dirt and debris and TSS is all solids, including dirt, which is suspended in water as it flows downstream.

Research suggests that when turbidity levels exceed four Nepheleometric Turbidity Units (NTU) macroinvertebrates (stream insects) are negatively impacted. Coho salmon will avoid waters with greater than 70 NTU (Oregon Department of Environmental Quality, 2014). Washington State Department of Ecology sets TSS as a high concern when levels exceed 275 mg/L and a moderate concern when TSS exceeds 33.

In Bothell 66% of sites were over the 4 NTU threshold, negatively impacting stream insects. For TSS 33% of sites were considered a moderate concern for TSS at some point during sampling.

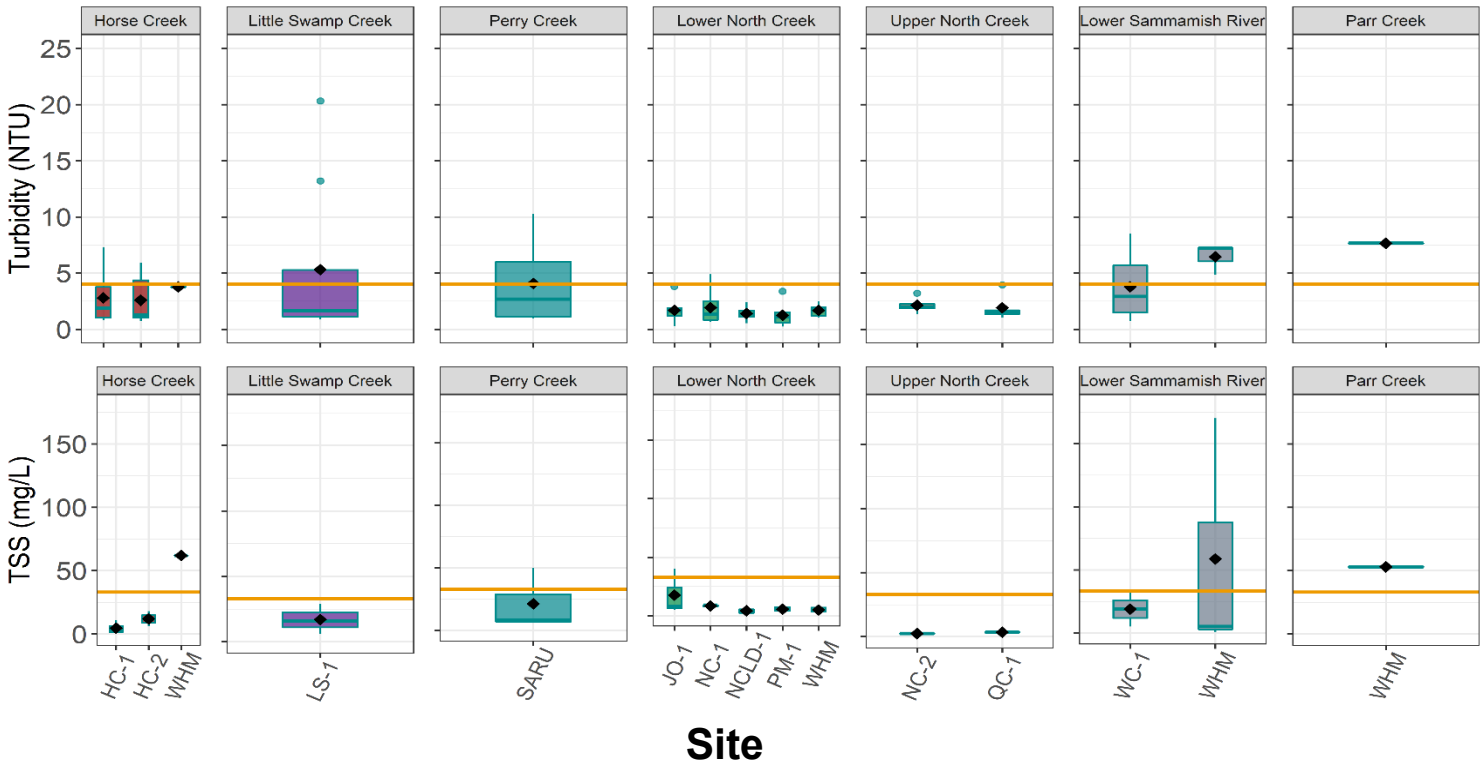
How Does Stormwater Affect Sedimentation?

Elevated sediment in stormwater and streams found in urban areas is often from landscaping activities, construction, accumulation of dirt and debris on road shoulders or other impervious areas, and any other earth moving actives. As rain falls and picks up exposed soil in these areas it flows into stormwater features that typically proceed untreated to local water bodies.

The best way to reduce sedimentation in local water bodies is to reduce the amount of exposed soils in the area. The City and State permit large construction projects which require sediment control measures. As a homeowner, anytime there is earth disturbing activities it helps to cover exposed dirt with straw, mulch, or even a tarp until seeding or other vegetation can establish.

Turbidity	Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Perry Creek	Upper North Creek
	N	15	8	38	9	1	8	10
	Mean	2.769	5.306	1.586	4.667	7.65	4.072	2.022
	Max	7.3	20.32	4.89	8.51	7.65	10.25	3.96

TSS	Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Perry Creek	Upper North Creek
	N	6	3	19	5	1	3	4
	Mean	16.667	17	7.526	42.8	53	21.333	3
	Max	62	29	40	170	53	50	4



Results: Dissolved Metals

Dissolved metals in streams have varying effects on aquatic organisms based on the concentration of the metal, metal type, hardness of water, dissolved organics concentration, and aquatic species. In general, sub-lethal metal toxicity alters fish behavior in many ways, such as respiration, feeding, and predator avoidance (Henry, Mary G., and Gary J. Atchison, 1991). Specific metals such as copper have negative impacts on the olfactory (sense of smell) nervous system of salmon (Baldwin, David H., et al, 2003). Even low levels of copper negatively impact salmon by preventing them from avoiding predators or finding spawning locations.

Water quality standards are set for copper, zinc, and lead based on dissolved fractions found in streams and the hardness of the water. A value of 50 mg/L for hardness was used to develop benchmarks for metals in Bothell to keep consistent benchmark levels. One site on Horse creek failed to meet the acute toxicity benchmark levels for zinc and one site on Junco Creek failed to meet the chronic benchmark levels for lead. All other sites met benchmarks for copper, zinc, and lead.

Zinc

Zinc Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Perry Creek	Upper North Creek
N	6	3	19	5	1	3	4
Mean	31.0	5.45	1.672	8.167	0.92	2.276	1.756
Max	145	6.54	9.18	26.5	0.92	2.77	3.23

Copper

Copper Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Perry Creek	Upper North Creek
N	6	3	19	5	1	3	4
Mean	0.799	1.557	0.381	1.137	0.1	0.834	0.842
Max	1.4	2.22	0.88	1.82	0.1	1.86	2.04

Lead

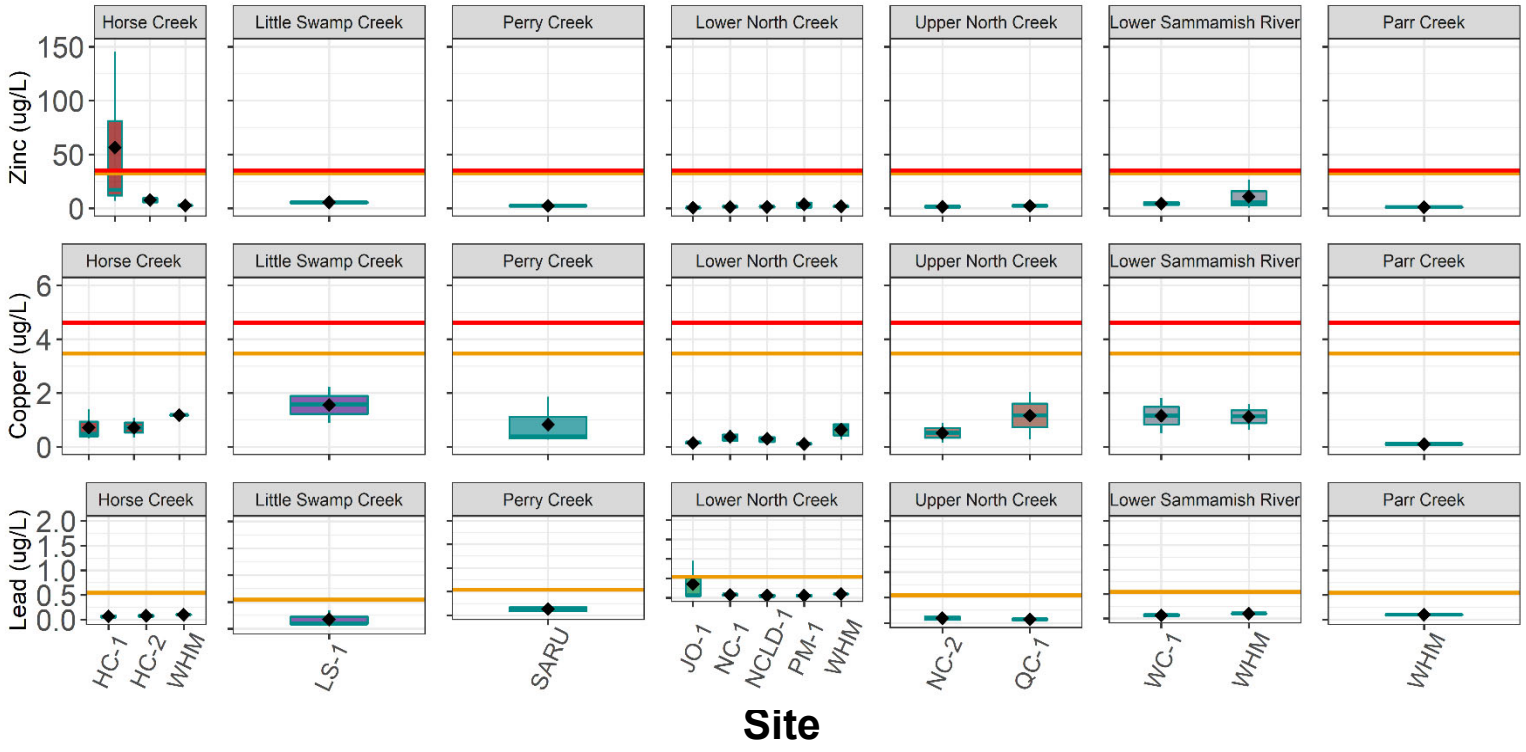
Lead Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Perry Creek	Upper North Creek
N	6	3	19	5	1	3	4
Mean	0.077	0.178	0.124	0.086	0.1	0.132	0.081
Max	0.1	0.351	0.95	0.1	0.1	0.22	0.155

How Does Stormwater Affect Dissolved Metals?

Metals in stormwater come from a variety of sources. Major sources of zinc in stormwater include: galvanized surfaces such as rooftops and fences, tire wear products, brake pads, vehicle oils, and fertilizers. Major sources of copper include: herbicides/fungicides, vehicle brake pads, and tire wear products. Major sources of lead include: ammunition and lead shot, roof runoff, and vehicle brake pads.

To reduce metals in stormwater and local water bodies, reducing the amount of herbicides and fertilizers can help. For large galvanized surfaces coatings can be added. Maintaining leaking vehicles to prevent oil drips also help.

Reducing pollutants at the source is the most effective way to decrease pollution in local water bodies but forms of stormwater treatment are also implemented by the City to reduce metals in stormwater.



Results: Nutrients

Excess nutrients in streams and lakes that aren't naturally high nutrient systems can cause eutrophication which increases algae production and can decrease dissolved oxygen in lakes and slow moving streams. As algae dies and sinks to the bottom of a stream or lake, it starts to decompose and the bacteria responsible for decomposition uses the available dissolved oxygen in the water body. Lower dissolved oxygen has direct effects on aquatic organisms as stated earlier.

Benchmark levels were developed using Washington State Department of Ecology's water quality index for specific parameters (Nitrogen and Phosphorous). For nitrogen, the moderate concern benchmark (yellow) is set at 0.58 mg/L and high concern benchmark (red) is 0.98mg/L. For Phosphorous, the moderate concern benchmark is 0.04 mg/L and the high concern benchmark is 0.178 mg/L.

In Bothell 99% sites were considered a high concern for nitrogen and 21% were considered a high concern for phosphorous. Of the remaining sites, the rest were of moderate concern for both nitrogen and phosphorous. In most systems, phosphorous is the limiting nutrient and therefore the most important to reduce.

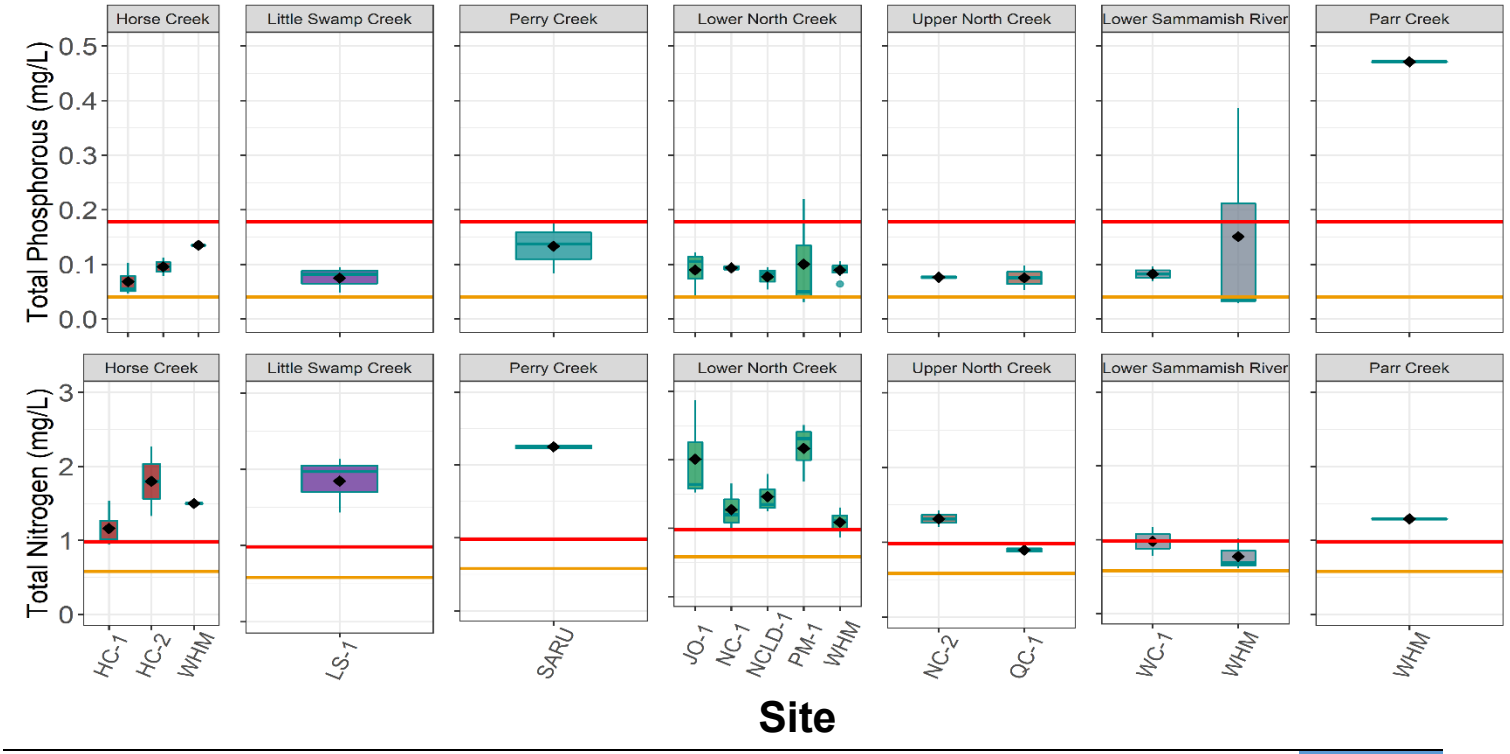
How Does Stormwater Affect Nutrients?

Excess nutrients in stormwater primarily come from overuse of fertilizers and from animal waste. Phosphorous can also be found in dishwashing detergent. Leaking septic systems can be a source of nutrients because of this.

The best way to reduce nutrient inputs into stormwater is to implement natural lawn care. By doing this you can reduce the amount of fertilizer used on lawns. Similar to reducing fecal coliform, picking up pet waste and inspecting/maintaining septic systems help reduce nutrient inputs as well.

Phosphorous	Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Perry Creek	Upper North Creek
	N	6	3	19	5	1	3	4
	Mean	0.088	0.075	0.09	0.123	0.471	0.133	0.076
	Max	0.135	0.095	0.22	0.386	0.471	0.18	0.098

Nitrogen	Stats	Horse Creek	Little Swamp Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Perry Creek	Upper North Creek
	N	6	3	19	5	1	3	4
	Mean	1.43	1.843	1.492	0.855	1.29	2.25	1.103
	Max	2.27	2.13	2.874	1.176	1.29	2.29	1.421



Results: Macroinvertebrates (B-IBI)

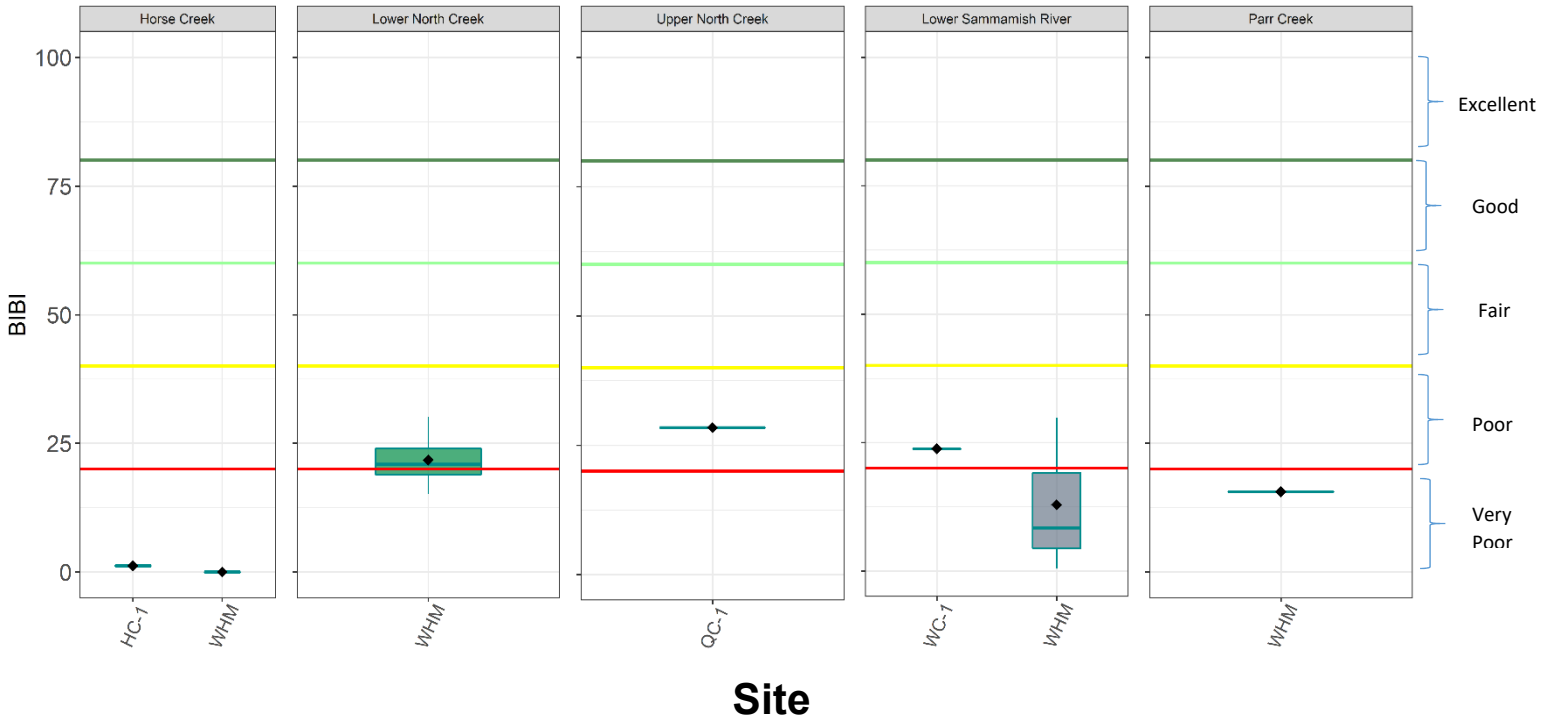
Stream macroinvertebrates (stream bugs) can be seen by the naked eye and live in or near the streambed. Monitoring for stream macroinvertebrates is important because they are a strong indicator of water quality or substrate impairment due to variable abilities to survive certain stressors among different species, such as pollution from stormwater.

Macroinvertebrates give good information for surface water managers because they:

- Are found in all habitats within a stream (Arzina et al, 2006).
- Are sensitive to pollution, and species richness/abundance can be used to infer about pollution in streams.
- Have a standardized scoring system across Puget Sound Lowland streams to determine impairment (Puget Sound Stream Benthos, 2020).
- Play an important role in the food web for fish, birds, and other wildlife.

B-IBI scores are used to evaluate macroinvertebrate health and are ranked as follows: 0-20 = Very Poor, 20-40 = Poor, 40-60 = Fair, 60-80 = Good, 80-100 = Excellent. In Bothell 60% sites were considered very poor for biologic health, while the remaining 40% were considered poor. Horse Creek had significantly lower B-IBI scores than other sites sampled in 2019.

Macroinvertebrates	Stats	Horse Creek	Lower North Creek	Lower Sammamish River	Parr Creek	Upper North Creek
	N	2	7	4	1	1
	Mean	0.6	21.057	15.625	15.6	28.4
	SD	0.849	5.115	13.524	NA	NA
	Median	0.6	19.8	16.1	15.6	28.4
	Min	0	15.2	0.5	15.6	28.4
	Max	1.2	30.2	29.8	15.6	28.4



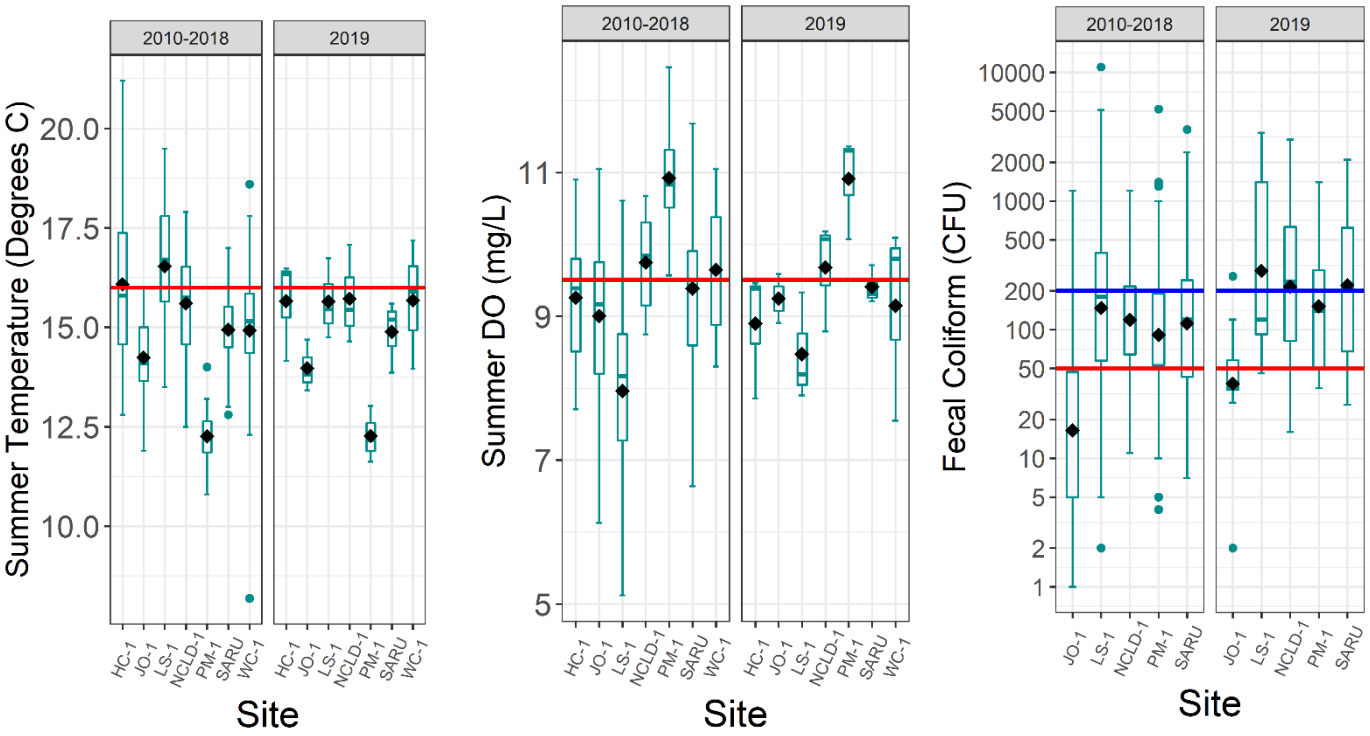
How Does Stormwater Affect Macroinvertebrates (Stream Bugs)?

Macroinvertebrates are scored using the Benthic Index of Biotic Integrity (B-IBI) which is determined by the number and diversity of different species found in a stream. Since certain species of macroinvertebrates are negatively impacted from pollution, scientists can evaluate the health of a stream from identifying macroinvertebrates found living in the stream.

Stressors that impact macroinvertebrates include common pollutants such as sediment, metals, and dissolved oxygen. As mentioned in previous sections, stormwater contributes to these issues in many different ways. A stream's macroinvertebrate health gives a great indication of potential issues found in that stream's watershed, which in urban areas can often be related to stormwater.

Summary

Overall, in 2019 several sampling locations in Bothell streams are failing to meet water quality standards or benchmarks for multiple parameters. This is consistent with previous years' sampling and surrounding cities results. Below is a graph showing temperature and dissolved oxygen (DO) were similar to previous years while fecal coliform was slightly higher than previous years. These three parameters consistently fail to meet water quality standards in Bothell. Other parameters didn't have as much data from the previous decade to compare 2019 results.



Nutrients and fecal coliform had the highest percentage of failure to meet standards or benchmarks in 2019. This makes since because higher fecal coliform bacteria indicates the presence of fecal matter which also contains concentrated amounts of nutrients. Dissolved metals generally met benchmarks, except for a few samples which occurred during rain events. In-stream sediments had a mix of sites that failed to meet benchmarks, typically taken during rain events. Metals and sediment are also commonly correlated due to the inherit behavior of metals to sorb onto sediment particles suspended in water. Macroinvertebrate health was considered very poor or poor for all sites sampled in 2019.

The City will continue to monitor these parameters in 2020 and implement proper surface water and land use management to reduce the amount of pollutants to the greatest extent practicable. There are some things that Bothell residents can also do to help reduce pollution:

1. Pick up pet waste
2. Implement natural yard care practices
3. Inspect vehicles and reduce drips from vehicle fluids
4. Inspect and maintain septic systems
5. Report spills to Bothell's spill hotline when you see them: 425-806-6750

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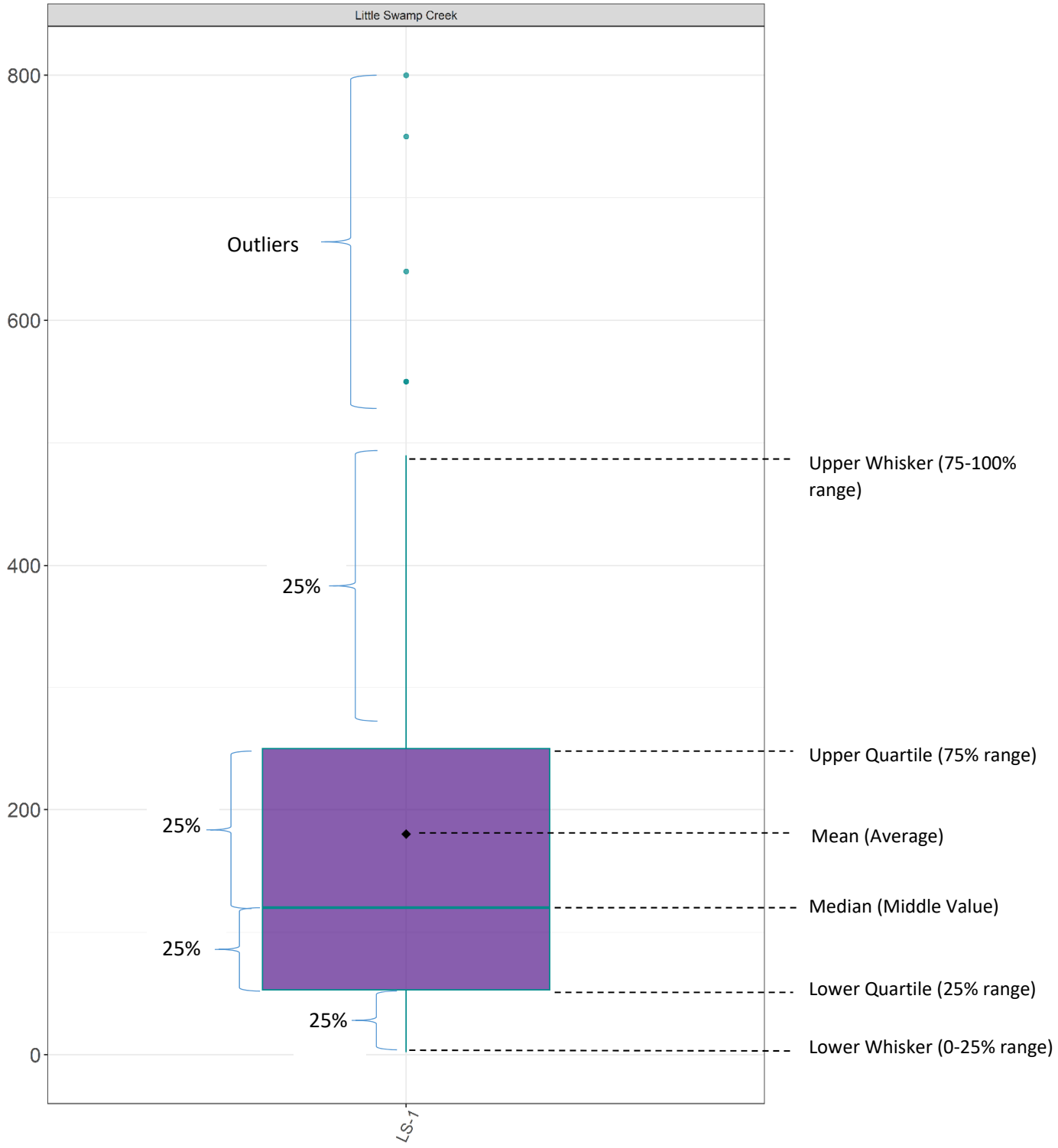
APPENDIX A: How to Read a Boxplot



A boxplot is a great way to show the distribution of results from sampling. The median gives the middle value (not the average) while the mean gives you the average of all the results. The box shows you the interquartile range (25-75%) excluding outliers. The whiskers show you 0-25% (lower) and 75-100% (upper) range of the results. Outliers are considered values that are numerically distant from the rest of the data. Mathematically, outliers are outside 1.5 times the interquartile range (box).